Sustainability - delivering what we promise

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Summary

Energy fuels the world's economy and is essential to maintain our civilisation. In the next 50 years supplies of fossil fuels will become scarce and the climatic impacts of burning fossil fuels will start to impact on our weather systems. As a result there is international concern over the impact of global warming and growing pressure to mitigate any adverse effects.

Buildings are responsible for around a third of all energy consumption and over 40% of the EU's Carbon Dioxide emissions. Therefore, as Building Services Engineers, we are in a key position to help reduce these emissions and the corresponding impact on global warming. In doing so we face a real challenge, as the altruistic desire to save energy is not often supported by the commercial realities of today's competitive international markets.

This paper looks at the background to sustainable design issues and the prospects of incorporating practical engineering solutions and their real cost benefits. The paper also looks at the recent legislation to back the UK governments aim to reduce by 60% carbon dioxide emissions by 2050.

1.0 The issues

Energy consumption levels reflect the standard of life enjoyed by the consumers. The greater the level of consumption, the greater the affluence of a nation and its people. In consequence any dramatic reduction in consumption, will result in a corresponding reduction in the standards of living enjoyed by the consumer. Politically, pressure to reduce energy consumption would prove unpopular, both by the affluent energy profligate nations, and developing nations looking to 'fuel' their economies.

Any move to reduce energy consumption will therefore need strong drivers. Thirty years ago the fuel crisis provided a driver. Over the last decade increasing concern over the impact that escalating energy consumption has on our environment has resulted in a new and powerful driver - at least for the informed. It has attracted significant international concern, with a strong call to reduce our carbon dioxide emissions. This will essentially require a reduction in energy consumption, or finding ways of producing energy without burning fossil fuels.

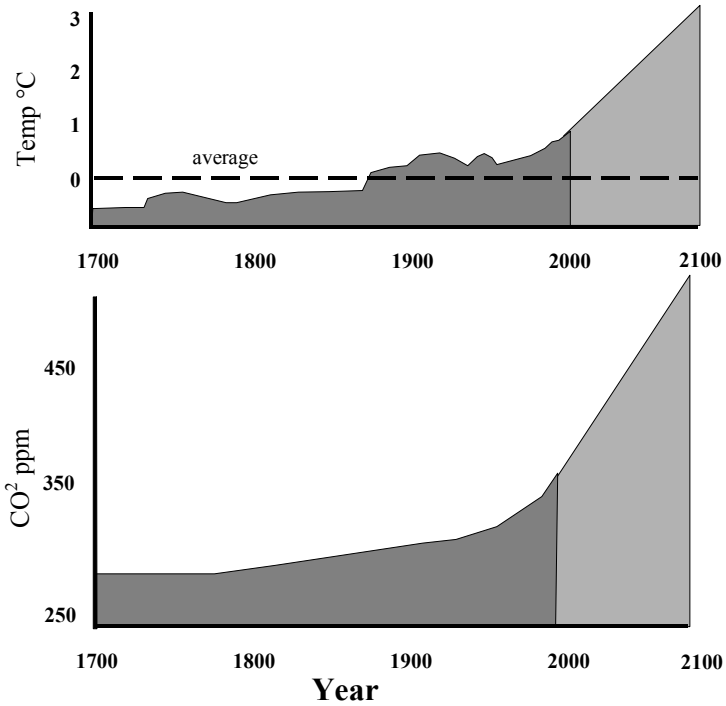
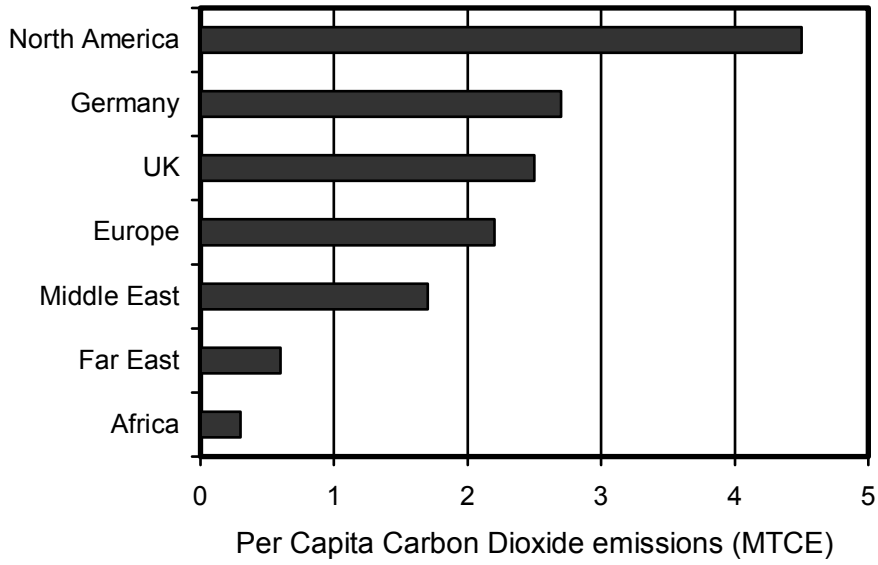


Figure 1. Trends in temperature and CO_2 levels

Since the start of the industrial revolution human activities have created an imbalance in the carbon cycle, natures natural ability to balance CO_2 production with the rate of CO_2 absorption by photosynthesis. The correlation between energy consumption and atmospheric CO_2 levels are shown in figure 1.

The impact of the increase in the earth's surface temperature has already been felt by measurable changes such as:

- Ice caps retreating - snow cover in the Alps has reduced
- Global mean sea level rose by an average of 1-2mm a year during the 20th century
- Summer arctic ice has thinned by 40% in recent decades
- Use of the Thames barrier has increased from once every two years in the 1980's to an average of six times a year over the past 5 years
- A tenfold increase in weather related economic losses in the last 40 years



Scientific opinion that the burning of fossil fuels is responsible for global warming is now almost unanimous. Given the predicted impact of global warming on our weather systems and ecology any measures to mitigate the effects must be fully considered including:

- reducing the consumption of fossil fuels
- increased use of renewable resources – *both in terms of energy and materials*
- avoidance of waste/maximise use of recyclable materials
- Increased flexibility of use

It is clear that building services engineers can have considerable influence in each of these areas.

2.0 Reducing consumption of fossil fuels

Buildings are responsible for over 43% of the EU's energy consumption, and 46% of the UK's CO_2 emissions. A vast majority of this is energy is provided by fossil fuels, with less than 3% provided from renewable resources.

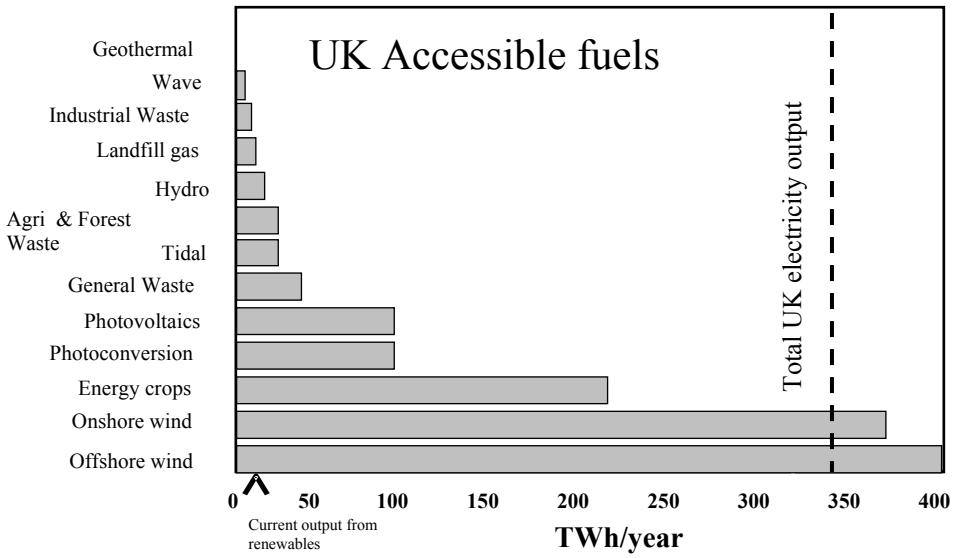


Figure 2. UK's accessible renewable resources

The variety and extent of renewable energy resources available in figure 2 is comforting. This clearly shows that, in theory at least, the UK's total electricity demand could be met by wind turbines alone. In practice this is unlikely, and a mixed basket of resources are the most practical proposition. In terms of total energy figure 3 shows that we only need to harness 1.4% of the solar power falling on the UK to meet our energy demand.

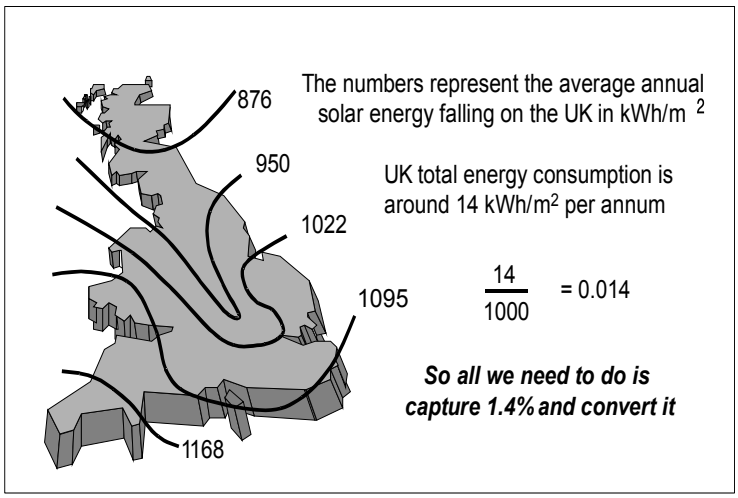


Figure 3 UK Solar Energy

In practical terms this presents many challenges, but illustrates the overall potential renewable resources present. Direct conversion of solar energy to electricity using photovoltaic (PV) cells is a proven technology. However, with an output of 140kWh/m^2 per annum and a capital cost around £500/m^2 other investments in CO_2 in reducing technology such as passive solar designs reap better rewards, unless the PV arrays form a fully functional part of the building façade.

By use of regulations we have improving the levels of thermal insulation in our buildings. In fact it is one of the reasons why the UK's CO_2 output has fallen over the last 20 years. As a result of increased insulation standards energy needed to heat the ventilation air has become a more significant component of total building heat loss.

Regardless of whether the space is mechanically ventilated, or naturally ventilated, in winter ventilation air has to be heated to an appropriate temperature. If we look at the power required to heat 8l/s of ventilation air, (minimum fresh air rate per person) using a typical UK winter design temperature of - 3°C the load equates to approximately 230W.
If the same volume of air is heated via a mechanical ventilation system the fan power has to be added. Using a typical ventilation plant this would add a further 3W per l/s of air moved equating to an additional 24W to the 230W required. However, at least 16W of this will be converted into useful heat gain. If a heat recovery system with an efficiency of 75% is incorporated into the mechanical system this could reduce the power consumed by the system to around 90W.

Heating energy and CO_2 emission *(8 l/s ventilation air per person)*			
	Energy (Whr)	£/person/hr*	CO_2 Kg/h
Natural ventilation	230	0.0023	0.05
Simple mechanical ventilation	240	0.0030	0.06
Mechanical ventilation with heat recovery	90	0.0013	0.03

**Based on energy cost of £0.05/kWh for electricity: £0.01/kWh gas: 1 person per 10m^2*

Whist this is perhaps an overly simplistic calculation it clearly demonstrates the improved efficiency of using mechanical ventilation with heat recovery over natural ventilation in terms of energy, cost and reducing CO_2 emissions.

In a monetary economy cost considerations often mitigate against heat recovery installations. This would not be the case in a carbon economy. Simply put in financial terms the above example equates to some £10 per person per annum. When compared with say an average salary of £15,000 per annum it is easy to see why investors see greater potential by investing in improved staff performance.

This is why it is essential that we understand the impact that increased comfort level has on human performance. Data to demonstrate the generalised effect is available but not properly accepted. If precise data were available, that demonstrated that a given increase in comfort improved human performance by a quantifiable degree, the engineer would have a powerful analysis tool. And providing more for less is at the heart of sustainability.

In addition to any financial incentives to improve energy efficiency, in the UK and Europe there is growing pressure to reduce energy consumption from increasing legislation.

3.0 Legislative pressures

A number of legislative instruments have recently been introduced to reinforce the need to reduce energy consumption and promote the reduction in CO2 emissions.

In February 2003 the UK Government published an Energy White Paper that sets out how we might create a low carbon economy through the use of renewable energy and reduction in consumption. It acknowledges that climate change is real and that positive action is needed to mitigate the impact. Beyond the altruistic ambitions to reduce emissions the White Paper acknowledges that the UK will soon become a net importer of gas and oil with a corresponding potential threat to energy security.

The UK has 33% of Europe's Wind Capacity

Current *(2002)* EU installed capacity (MW)

Germany	12000
Spain	4830
Denmark	2880
Netherlands	688
Italy	785
UK	552
France	145
EU total	23000

The UK capacity represents 3% of European capacity

The main aims of the White Paper is a 60% cut in the UK's CO2 emissions by 2050 and eliminating fuel poverty by 2018, whilst promoting a competitive energy market and reliable energy supplies. It sets out a strategy for the next 20 years and aims for the following 30 years. Critics claim that it lacks hard-edged targets. It also unfairly places too much emphasis on electricity production, whist being light on measures to reduce heat and transport energy consumption. Many also question the Paper's assertion that the targets can be achieved at a cost of less than 2% of GDP. To achieve the reductions the White Paper promotes the use of more renewables, distributed generation, combined heat and power (CHP) installations, the use of fuel cells and the improvement of net metering arrangements (selling locally generated power back to the grid).

One of the few legislative documents referred to in the White Paper is the Building Regulations. In 2002 Approved Document Part L (Part J in Scotland) introduced new standards in energy efficiency in England and Wales. Whilst it's introduction caused some concern over the additional construction cost that the requirements imply, many believed that this did not go far enough. The White Paper signals the intent to bring forward the next revision of Part L to 2005. Pre-dating the White Paper by a month the European Parliament directive 2002/91/EC on the energy performance in buildings came into force, requiring that member states have legislation in place by 4 January 2006. The impact of this legislation is likely to attract considerable attention, given that it will require the inspection and certification of some 160 million buildings throughout the EU. The Directive is simply and clearly written and aims to improve the energy performance of buildings by the processes of assessment, labelling and regular inspection. To be successful considerable intellectual effort will need to be expended to convert the simply stated aspirations of the Directive into bullet-proof national legislation. Whatever the detail, this will place considerable additional work in the building services sector.

5.0 Operation and maintenance

Most building services engineers experienced in energy auditing will appreciate the significant potential that exists for reducing energy consumption in buildings. Savings of 10%, and arguably much more, could be achieved by good housekeeping measures and ensuring a watchful eye is kept on operating procedures and routines. We could do much more to minimise energy consumption by:

- improved control strategies
- better commissioning
- maintenance staff who understand how the systems are supposed to work
- regular monitoring and reviewing of system performance
- identification of poorly set up control systems.

The ability of a building management system to highlight poorly performing plant, by techniques such as expert systems, has been with us for 15 years or so - but we rarely if ever use them. One key area where we could make considerable reductions in energy consumption is in buildings where the occupancy rate varies, such as auditoria, museums, sports arena lecture theatres etc. To do so effectively requires a sensing device that will properly monitor the air conditions to control the fresh air supply. Yes, indoor air quality (IAQ) or CO_2 sensors are often used, but experience has shown that IAQ sensors have a very limited response to all but heavy pollutants. Whilst CO2 sensors provide better performance, they are not sufficiently robust for general use without regular re-calibration at a rarely seen in the maintenance of ventilation systems. A considerable reward awaits the inventor of a truly effective and robust air quality sensor.

For many years the standard of commissioning employed on building services installations has been criticised. With the Part L requirements and other impending legislation (discussed earlier) greater emphasis will be placed on more robust commissioning procedures, as the systems are more likely to come under closer scrutiny post completion.

6.0 Conclusion

In the past five years sustainable design has gone from a fringe interest to a desirable attribute. In the next 5 years it will become an essential part of the design and operation of our buildings. Building services engineers will have a key role in achieving these aims by delivering appropriate, well informed and balanced advice to our clients and building operators. To do so we must make sure that we properly equip and train our engineers so that they are able to produce practical and inventive sustainable environmental solutions for any particular set of circumstances. We will also need to play a key role in advising and informing government agencies so that they construct clear, consistent and workable guidance in delivering new legislative structures.

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